

PRIMARY TRIAGE OF MASS BURN CASUALTIES WITH ASSOCIATED SEVERE TRAUMATIC INJURIES

Atiyeh B.,¹ Gunn S. William A.,² Dibo S.^{3*}

¹ President, Euro-Mediterranean Council for Burns and Fire Disasters, Executive Editor, Annals of Burns and Fire Disasters, Clinical Professor, Plastic and Reconstructive Surgery, American University of Beirut Medical Center, Beirut, Lebanon

² President Emeritus, Euro-Mediterranean Council for Burns and Fire Disasters, La Panetière, Bogis-Bossey, Switzerland

³ Chief Resident, Department of Surgery, Division of Plastic, Reconstructive and Aesthetic Surgery, American University of Beirut Medical Center, Beirut, Lebanon

SUMMARY. A key aim in any mass disaster event is to avoid diverting resources by overwhelming specialized tertiary centers with minor casualties. The most crucial aspect of an effective disaster response is pre-hospital triage at the scene. Unfortunately, many triage systems have serious shortcomings in their methodologies and no existing triage system has enough scientific evidence to justify its universal adoption. Moreover, it is observed that the optimal approach to planning is by no means clear-cut and that each new incident involving burns appears to produce its own unique problems not all of which were predictable. In most major burns disasters, victims mostly have combined trauma burn injuries and form a heterogeneous group with a broad range of devastating injuries. Are these victims primarily burn patients or trauma patients? Should they be taken care of in a burn center or in a trauma center or only in a combined burns-trauma center? Who makes the decision? The present review is aimed at answering some of these questions.

Keywords: burn disaster, fire disaster, casualty triage, preparedness

Introduction

Pre-existing trauma systems and protocols and disaster plans are designed to address common management goals, and to ensure best possible practice in unusual circumstances. A key aim in any mass disaster event is to avoid diverting resources best used for complex patients by overwhelming specialized tertiary centers with minor casualties.¹ The most crucial aspect of an effective disaster response is pre-hospital triage at the scene. Correct triage assists in the maintenance of surge capacity and plays a vital role in the initial assessment and appropriate evacuation of victims to the necessary sites of care capable of managing their injuries and avoids inappropriate resource allocation and use.¹⁻³

Triage is a complex dynamic process of sorting casualties by priority according to severity of injury and the urgency with which care is needed. It has developed from a wartime necessity to a civilian tool to ensure that constrained medical resources are directed at achieving the greatest good for the greatest number of people.⁴⁻⁷ Several primary and secondary triage tools have been developed but evidence to support the use of one triage algorithm over another is limited.⁵

There appears to be a scarcity of burn specialists and specialist burn beds for all the disasters involving burns, in whatever country.⁸ Although the concept of triage is accepted within the burn care community, no formal guidelines exist that define how specific patients should be "ranked" after burn injury.⁷ Existing triage and acuity scoring systems are suboptimal and are biased toward traumatic injuries, usually ignoring mitigating factors such as alcohol and drug use and environmental exposures and are not optimal for "resource-intensive" injuries such as burns, which require a uniquely great commitment of supplies, personnel, and time to produce optimal outcomes.^{4,7}

Total body surface area (TBSA) burned provides a rough, objective index of injury severity.⁷ It is therefore obvious that accurate assessment of the extent of the burn injury is critical for the appropriate application of triage criteria.⁷ Unfortunately, when inexperienced personnel, including physicians, estimate burn size, significant errors occur,⁷ making accurate burn triage under field conditions impracticable.⁹ Moreover, other factors, most importantly patient age and inhalation injury, affect survival profoundly. These confounding factors can make the prioritization of burn patients difficult in a mass casualty situation.⁷

* Corresponding author: Dibo S., MD, Chief Resident, Department of Surgery, Division of Plastic, Reconstructive and Aesthetic Surgery, American University of Beirut Medical Center, Beirut, Lebanon. E-mail: saaddibo@yahoo.com

Burn disasters

Almost 70% of disasters, classified as more than 20 dead at the scene, can result from natural causes (volcanic eruptions, earthquakes in urban settings, large forest fires, etc.), but most often are man-made (fires with explosions, pipeline ruptures, building collapse with gas leaks, coal mine disasters, agricultural silo explosions, fires in public places, fires involving transportation, terrorist attacks, etc.).¹⁰⁻¹³ It is estimated also that 20-30% of injuries from mass casualty events result in serious burns, many requiring specialized care.¹⁴ However, in spite of large numbers of casualties, the actual number of survivors with severe burns may be relatively small.⁸ Even though there are relatively few patients with severe burns following a mass disaster event when compared with the number of lives lost,¹⁵ burns occur in only a small number of survivors but they very rarely happen in isolation.^{10,16} In most major burns disasters, the victims mostly have combined trauma burn injuries and form a heterogeneous group with a broad range of a devastating constellation of injuries,^{17,18} with injuries from blasts or chemical agents, greatly contributing to the pattern and severity of injuries.¹

Unfortunately, burn injuries are a major determinant of late deaths and have the highest specific mortality (40%) among all types of injury.¹⁰ It is also reported that many mass casualty burn patients have a high severity of injury (30% with an Injury Severity Score of 25 or higher) and that most combined burn and trauma patients require ICU (55%). Furthermore, patients with combined burn and trauma have the longest hospital stay.^{10,11} It is thus critical to determine how rescue and burn care should be organized in the event of such a disaster.¹²

Mass casualty burn victims represent the greatest challenges at the scene where triage decisions are made.¹⁰ Burns > 20% TBSA are considered "severe" in the setting of a mass casualty incident.^{1,15} Although the management of individual burn cases is known, it is important to consider a more systems-based perspective, to enable coordination and the most effective resource allocation in times of disaster.¹

Although only relatively small numbers of victims require hospital admission and specialized care, these "small" surviving numbers necessitate a significant increase in resource allocation and can easily overwhelm hospital surge capacity, in particular, burn centers which typically have scarce bed resources.^{12,15} From the study of recent disasters it is observed that the optimal approach to planning is by no means clear-cut and that each new incident involving burns appears to produce its own unique problems not all of which were predictable.⁸

Are these victims primarily burn patients or trauma patients? Should they be taken care of in a burn center or in a trauma center or only in a combined burn-trauma center? Who makes the decision?¹⁰ Unfortunately, there is still

no comprehensive state, regional, or national disaster plan that incorporates the care of patients with both burns and other serious injuries to answer all these questions.¹⁰

Triage guidelines for mass burn disasters

Classical on-site triage in mass casualty incidents is usually initiated according to standardized international procedures and algorithms by paramedics and/or emergency physicians.^{2,3,12} However, burn triage differs from classical triage of trauma victims in several ways because evaluation of burn severity necessitates a whole body examination difficult to perform in a potentially hostile environment and they should be initially monitored very closely as their condition can deteriorate rapidly.¹² Moreover, unlike some other types of traumatic injury, burns are visually intimidating, often causing the wound to become the first focus of attention, rather than the overall condition of the person.¹⁴

Major burns are among the most complex trauma cases to manage, given the constantly evolving pathophysiology of the burn wound, the potential for co-existent multisystem trauma, and the need for multidisciplinary care. Victims require specialized care both in the acute phase and in the subsequent weeks and months.¹ Following a mass disaster, plans should focus on the triage and distribution of casualties to hospitals avoiding at the same time swamping the local hospital or Burn Unit with cases that do not need immediate highly specialized care.^{8,15} The requirement for ICU beds when treating burn patients is frequently the limiting factor in the acute response to mass casualty incidents.¹⁵

Under the difficult conditions at the disaster scene, considerable skills are required to identify and categorize patients, and make sure they are sent to appropriate hospitals with adequate facilities and resources.⁸ Accurate estimation of burn extent and depth is not flawless.^{7,9} Moreover, attempts to predict the requirements of patients with massive burns are far more problematic and uncertain,¹⁵ particularly when associated with other major traumatic injuries. Burn patients require large amounts of human, infrastructural and consumable resources very difficult to quantify. The delayed demands on such resources are increasingly difficult to measure.¹⁵

Ideally, patients with severe burns should be transferred to burns centers, other trauma patients to non-burn trauma centers, and those with time critical conditions to other tertiary hospitals. In the event of overwhelming numbers of casualties, secondary transfer of patients to distant burns centers for further management may be necessary to ensure adequate definitive treatment.¹ The presence of people with burns >50% TBSA in a mass casualty cohort increases both acute and longer-term resource requirements exponentially, and also greatly extends the length of time

of increased demands This would significantly complicate decision-making with respect to resource allocation.¹⁵

Existing triage systems are mostly based on the extent of TBSA burned and on burn severity scoring for determination of the required management as for ambulatory, non-specialized hospitalization, or burn center referral.^{7,12,19-23} Any patient with a burn injury >20% TBSA is considered to have a severe injury.¹ In the setting of a disaster with mass burn casualties, burns referral centers should theoretically be reserved for the management of the more severe and complicated injuries; patients with burns <20% TBSA may be evacuated to a non-specialist facility; patients with severe burns must be diverted to specialist burns/trauma centers to optimize their chances of survival.^{1,15} However, specialist burns services have extremely limited capacity to deal with large numbers of complex patients,¹ thus critical decisions must be made about who will benefit most from the available resources and facilities.

There is a general consensus that in a situation with resource restrictions or large numbers of casualties, hospital care can be delayed for patients with burns of 20% or less of the total body surface. Similarly, expectant care should be applied to patients with burns exceeding 70% TBSA and the available care facilities and resources applied to those with burns from 20% to 70% TBSA. With even greater restriction of health care availability, the upper limit of the maximum treatment group should be reduced by stepwise decrements of 10% until the surgical workload matches available resources. Triage modifiers also include significant coexisting inhalation injury and associated mechanical injury, each of which lowers the upper limit of the maximum treatment group by 10%. Conversely, burns of the hands, face, feet, and perineum, occurring in patients with lesser TBSA burns, will increase the medical care necessary for such patients.^{24,25}

It is obvious that these described categorizations are somewhat arbitrary and are not ideal in the majority of mass casualty disasters with associated burn injuries. Invariably most lead to under-triage or over-triage of burn patients in the likelihood of associated major fractures, vascular injuries, injuries to the brain and spinal cord, or inhalation burns all of which carry a worse prognosis.

Discussion

Triage in routine civilian practice identifies individuals with the most severe injuries who are likely to need the quickest and most concentrated life-saving treatment. Priorities in mass casualty situations, however, may be forced to change. Some severely injured patients, although theoretically salvageable, may be denied treatment; instead limited resources are used to care for those patients with the highest likelihood of survival.⁷ Unfortunately, many triage systems have serious shortcomings in their method-

ologies and no existing triage system has enough scientific evidence to justify its universal adoption.²⁶ Despite several arbitrary attempts at categorization of mass burn injuries, no formal evidence-based guidelines exist that define how specific patients should be ranked,⁷ particularly when associated with other severe injuries.

Assessment of burn severity factors is decisive for placing the patient in the appropriate treatment center.¹² Burn size itself provides a rough, objective index of injury severity. Based on anticipated outcomes compared with resource allocation extrapolated from civilian practice and burn injury survival curves, burn size has been fundamental to the elaboration of various burn injury triage tools and triage decision tables.^{7,12,14,19-23} The Triage-To-Benefit Ratio Table for patient assessment was developed by the American Burn Association. It provides emergency management services (EMS) with a reliable method for triaging large numbers of burn casualties in a timely manner. The table is based upon evaluating two risk factors: age and percentage TBSA burns.¹⁴

Unfortunately, significant errors occur when burn size is estimated even by experienced personnel.²⁷ In a triage scenario, such a mistake could literally mean the difference between life and death.⁷ Moreover, the paucity of information supporting some of our concepts about burn survival has been recently highlighted.⁷ Patients with large TBSA burned are increasingly rare, and data on their rates of survival are sparse. With such limited data, confidence limits are extremely wide and mandate that survival predictions be interpreted cautiously.⁷ Nevertheless, it is presumed that the survival statistics quoted are obtained under optimal circumstances from dedicated burn centers with abundant supplies, personnel, time, and financial support to devote exhaustive and meticulous care to every patient.⁷ In a mass disaster situation, survival figures may be quite different.

Association of frequently encountered other serious traumatic injuries in a mass disaster situation unfortunately has been given little place in the elaboration of burn triage tools. Other confounding factors, such as inhalation injury in addition to the fact that burns are singularly "resource-intensive" injuries requiring uniquely great commitment of supplies, personnel, and time to produce optimal outcomes, make the prioritization of burn patients difficult in a mass casualty situation.⁷

In the face of a burn disaster situation, a common response is simply to send all patients immediately to a burn center. While burn patients do require the kind of specialized, comprehensive care available only at burn centers, there are other, more vital, patient care needs that must be evaluated and addressed before planning proper treatment.¹⁴ Though implementing at the scene a primary burn disaster triage tool such as the standard triage sieve-sort methodology based on START (Simple Triage Assessment and Rapid Transport) and SAVE (Secondary As-

assessment of Victim Endpoint)^{28,29} is essential, it may not be sufficient. Serious consideration must be given to the associated injuries. To overcome the pitfalls of current triage tools, it has been suggested that on-site triage by specialized burn teams can improve the usual triage outcome. A better estimation of burn injury severity, which integrates assessment of surface, depth, and location of the burns, as well as the risk of inhalation or blast injury, may be achieved. This improves also the estimate of the probability of survival that will determine intensity and type of care and facility required.¹²

Whether a given casualty must be considered primarily a burn patient or a trauma patient will depend on the most serious injury that ultimately determines prognosis and final outcome. Regardless, any casualty with a TBSA burn > 20% is better attended to by a team knowledgeable in burn treatment and thus evacuated to a facility with such expertise. Victims on the other hand with relatively minor burns and severe traumatic injuries should follow triage guidelines relative to these injuries.

Although the operational and clinical implications of using multiple triage systems at the same incident are unknown, it seems reasonable to assume that for operational simplicity, communication interoperability, and clinical efficiency it is preferable for all of the responders at a given incident to use the same triage system, or at the very least operate from some common elements.²⁶ Unfortunately, fragmentation and non-standardization of triage tools is a major handicap for proper planning and response following most disaster scenarios. Since they most frequently result in several injury patterns and since responders from multiple agencies using different triage tools may be involved, there is a need for model uniform core criteria for mass casualty triage.²⁶

Globally, mass-casualty primary triage systems and all their components must apply to all ages and populations of patients and must be applicable across the broad range of mass casualty incidents with the assigned triage category for each patient visibly identifiable (triage tags, tarps, markers). They must be simple, easy to remember, and amenable to quick memory aids and must be rapid to apply and practical for use in an austere environment.²⁶ Needless to say that triage systems are resource dependent and the system must allow for dynamic triage decisions based on changes in available resources and patient conditions as well as in improved knowledge and scientific evidence.²⁶

It is also probably useful to form special burn assessment teams. A team, however, should not be deployed to the disaster area; it should instead move through the primary admitting hospitals to examine and assess priority cases in a relatively calm environment. Cases needing specialist Burn Unit/Centre care, if not already selected *in situ* at the initial incident site, would then be transferred to appropriate hospitals, leaving the more minor problems to be

looked after in peripheral hospitals not necessarily by plastic or burn specialists but by general surgeons.⁸

Conclusion

Disasters have been defined as situations in which the destructive effects of an event overwhelm the ability of a given area or community to meet the demand for health care.³⁰ To meet resource shortages, triage at the scene is the cornerstone of any mass disaster planning. Following a mass burn disaster the importance of primary triage cannot be overemphasized due to the resource-intensive nature of burn injuries. Any under-triage would overwhelm the existing limited facilities while over-triage would condemn otherwise salvageable victims. Triage decisions are not easy particularly in the presence of confounding risk factors such as associated severe traumatic injuries particularly since there is still no comprehensive disaster plan that incorporates the care of patients with both burns and other serious injuries.¹⁰ Moreover, assessment of burns for initial triage decisions is not without major flaws even when performed by experienced senior officers. Additional difficulties facing proper primary decisions arise from the fact that modern burn treatment have evolved from the premise that all patients are potentially salvageable; as a result, surgeons increasingly are unfamiliar and uncomfortable with anything less than the most aggressive treatment.⁷

There is no single moral theory that is able to successfully address every moral dilemma that is posed, and many will be posed during any mass-care events when resources are scarce.³⁰ Many factors will need to be weighed and resources must be utilized in a prioritized manner to provide the greatest good for the greatest number of victims. Actions of first responders on the scene are crucial. The situation must be evaluated rapidly and as many hazards as possible must be mitigated rapidly. Subsequently an incident command must be established and victims rapidly assessed, triaged, rescued and evacuated.³¹ All decisions are aimed to improve the patient's chances of survival, and are based on knowledge, previous experience, and a problem-based assessment algorithm.³¹ This is easier said than practiced.

Mass casualty triage is a critical skill. Although many systems exist to guide providers in making triage decisions, there is little scientific evidence available to demonstrate that any of the available systems have been validated.^{5,26} Evidence to support the use of one triage algorithm over another is limited. Moreover, the most widely recognized mass-casualty triage algorithms in use today are not evidence-based. Currently, the lack of a standardized mass-casualty triage system that is well validated, reliable, and uniformly accepted, remains an important gap and the development of effective triage protocols is an important research priority.⁵

RÉSUMÉ. Un objectif clé après les désastres de masse de tous les types est d'éviter le détournement des ressources submergeant les centres tertiaires spécialisés de patients atteints de lésions mineures. L'aspect le plus crucial d'une réponse efficace aux catastrophes est le triage préhospitalier à la scène de l'accident. Malheureusement, de nombreux systèmes de triage présentent de sérieuses lacunes dans leurs méthodologies et aucun système de triage actuellement utilisé ne démontre de posséder les qualités scientifiques suffisantes pour justifier son adoption universelle. Par ailleurs, on observe que l'approche optimale pour la planification n'est pas nullement claire et que tous les cas de désastre par feu présentent des aspects particuliers non tous prévisibles. Dans la plupart des grands désastres par feu, la majorité des victimes présentent une association de brûlures et d'autres traumatismes et constituent un groupe hétérogène atteint d'une large gamme de lésions dévastatrices. Ces victimes sont-elles principalement des patients brûlés ou des patients traumatisés? Faut-il les prendre en charge dans un centre des brûlés ou un centre des traumatisés ou seulement dans un centre dédié aux soins des deux catégories de patients? Qui prend la décision? Les Auteurs de cette étude miment à répondre à certaines de ces questions.

Mots-clés: désastre par feu, patients brûlés dans les désastres, triage des victimes, état de préparation

BIBLIOGRAPHY

- Seifman M, Ek EW, Menezes H et al.: Bushfire Disaster Burn Casualty Management. The Australian "Black Saturday" Bushfire Experience. *Ann Plast Surg*, 67: 460-3, 2011.
- Masellis M, Gunn SWA: "The Management of Mass Burn Casualties and Fire Disasters". Kluwer Academic Publishers Group, Dordrecht, The Netherlands, 1995.
- Turris SA, Lund A: Triage during mass gatherings. *Prehosp Disaster Med*, 27: 531-5, 2012.
- Jenkins JL, McCarthy ML, Sauer LM et al.: Mass-casualty triage: Time for an evidence-based approach. *Prehosp Disaster Med*, 23: 3-8, 2008.
- Atiyeh BS, Hayek SN: Management of war-related burn injuries: Lessons learned from recent ongoing conflicts providing exceptional care in unusual places. *J Craniofac Surg*, 21: 1529-37, 2010.
- Saffle JR, Gibran N, Jordan M: Defining the ratio of outcomes to resources for triage of burn patients in mass casualties. *J Burn Care Rehabil*, 26: 478-82, 2005.
- McGregor JC: Major burn disasters: Lessons to be learned from previous incidents and a need for a national plan. *Surg J R Coll Surg Edinb Irel*, 2: 249-50, 2004.
- Mackie DP: Editorial: Mass burn casualties: A rational approach to planning. *Burns*, 28: 403-4, 2002.
- Cairns BA, Stiffler A, Price F et al.: Managing a combined burn trauma disaster in the post-9/11 world: Lessons learned from the 2003 West pharmaceutical plant explosion. *J Burn Care Rehabil*, 26: 144-50, 2005.
- Peleg K, Aharonson-Daniel L, Stein M et al.: Gunshot and explosion injuries: Characteristics, outcomes, and implications for care of terror-related injuries in Israel. *Ann Surg*, 239: 311-8, 2004.
- Potina M, Sénéchaud C, Carsin H et al.: Mass casualty incidents with multiple burn victims: Rationale for a Swiss burn plan. *Burns*, 36: 741-5, 2010.
- Fadeyibi IO, Jewo PI, Opoola P et al.: Burns and fire disasters from leaking petroleum pipes in Lagos, Nigeria: An 8-year experience. *Burns*, 37: 145-52, 2011.
- Conlon KM, Martin S: 'Just send them all to a burn centre': Managing burn resources in a mass casualty incident. *J Bus Contin Emer Plan*, 5: 150-60, 2011.
- Cleland HJ, Proud D, Spinks A et al.: Multidisciplinary team response to a mass burn casualty event: Outcomes and implications. *MJA*, 194: 589-3, 2011.
- Horner CWM, Crighton E, Dziewulski P: 30 years of burn disasters within the UK: Guidance for UK emergency preparedness. *Burns*, 38: 578-84, 2012.
- Van Hartena SM, Wellinc L, Perez RS et al.: Management of multiple burn casualties from the Volendam disaster in the emergency departments of general hospitals. *Eur J Emerg Med*, 12: 270-4, 2005.
- Brandt CP, Yowler CJ, Fratianne RB: Burns with multiple trauma. *Am Surg*, 68: 240-4, 2002.
- Masellis M, Ferrara MM, Gunn SWA: Fire disaster and burn disaster: Planning and management. *Ann Burns Fire Disasters*, 12: 67-76, 1999.
- Wellinc L, van Harten SM, Henny CP et al.: Reliability of the primary triage process after the Volendam fire disaster. *J Emerg Med*, 35: 181-7, 2008.
- Ahuja RB, Bhattacharya S: ABC of burns. Burns in the developing world and burn disasters. *BMJ*, 329: 447-9, 2004.
- Shrivastava P, Goel A: Pre-hospital care in burn injury. *Indian J Plast Surg*, 43: 15-22, 2010.
- Griffiths RW: Management of multiple casualties with burns. *Br Med J*, 291: 917-8, 1985.
- Barillo D: Planning for burn disasters: Lessons learnt from one hundred years of history. *J Burn Care Res*, 27: 622-34, 2006.
- Wetta-Hall R, Berg-Copas GM, Cusick Jost J et al.: Preparing for burn disasters: Predictors of improved perceptions of competency after mass burn care training. *Prehosp Disaster Med*, 22: 448-53, 2007.
- Lerner EB, Cone DC, Weinstein ES et al.: Mass casualty triage: An evaluation of the science and refinement of a national guideline. *Disaster Med Public Health Prep*, 5: 129-37, 2011.
- Atiyeh B, Gunn SWA, Hayek SN: State of the art in burn treatment. *World J Surg*, 29: 131-48, 2005.
- Carley S, Mackway-Jones K, Randic L et al.: Planning for major burns incidents by implementing an accelerated Delphi technique. *Burns*, 28: 413-8, 2002.
- Nocera A, Garner A: An Australian mass casualty incident triage system for the future based upon triage mistakes of the past: The Homebush triage standard. *Aust N Z J Surg*, 69: 603-8, 1999.
- O'Laughlin DT, Hick JL: Ethical issues in resource triage. *Respir Care*, 53: 190-7, 2008.
- Bates KD: Critical decisions. *EMS Mag*, 38: 47-50, 2009.

This paper was accepted on 23 January 2013.